REPORT: NASA PROPOSAL 60607

"Is there a young pulsar in PKS 1209−52?"

Introduction. Already, at the turn of the 1960's decade, theoretical cooling curves of neutron star were becoming available in anticipation of the beginning of X-ray astronomy (Chiu 1964; Chiu & Salpeter 1964). The scenario that emerged was that neutron stars were born hot (interiors of $T \sim 10^{11}$ K) and then rapidly cooled via neutrino emission from the interior to surface temperatures of a few million kelvins in $\sim 500 - 10^3$ yr. Neutron stars with surface temperature of $T \sim 10^6$ K and a radius $R \sim 10$ km determine the optimal detection band to be X-rays and the luminosity to be around 1 solar luminosity.

Since then, several neutron stars have been detected in the X-rays, however, mostly via their magnetospheric emission. Non-thermal X-radiation is radiated by pulsars which are capable of accelerating relativistic elections in voltage gaps in the pulsar magnetosphere. Pulsed thermal blackbody-like emission has also been observed in four energetic pulsars (Ögelman 1995), but in all these cases X-rays could be due to a reverse current of relativistic electrons bombarding and heating the surface (Cheng & Ruderman 1980); and not due to the surface cooling. In other words, it is very difficult to disentangle surface cooling emission from the total of X-rays observed from magnetospherically active pulsars. Therefore no firm cooling neutron star candidate has been discovered, despite constant scrutiny of the sky in X-rays during the last 20 years.

ASCA observations of PKS 1209−52. We have obtained Advanced Satellite for Cosmology and Astrophysics (ASCA) observations of a strong candidate for a cooling neutron star. This is the intriguing X-ray source 1E 1207.4−5209, a point-like source situated centrally the large diameter (81-arcmin) supernova remnant (SNR) PKS 1209−51/52 (Figure 1). The remnant is thought to be $\sim 10^4$ yr old. Using ASCA's superior capability for X-ray spectroscopy, we infer an absorbed blackbody emitter at a temperature of $\sim 3 \times 10^6$ K, with a luminosity of 0.5 solar luminosity, in agreement with a recent ROSAT result by Mereghetti et al. (1996). The radiating surface is ~ 30 km^2 (probably the area around the neutron star polar caps), a small fraction of the total surface of a neutron star (1200 km^2). The X-rays, however, are not pulsed. A new X-ray source discovered in the bright SNR Puppis-A (Petre et al. 1996) and 1E 1207.4−5209, are thus-far the best candidates for initial cooling neutron stars.

More interestingly, there are little signs of magnetospheric activity associated with 1E 1207.4−5209, which is usually in the form of a pulsar or a pulsar-powered synchrotron nebula. We hypothesize that the neutron star was born a weak pulsar, i.e., with a weak dipolar magnetic fields and/or slow-rotation when compared to energetic young pulsars such as the Crab or Vela pulsars. This evidence is intriguing, in that a significant birthrate for weaker pulsars would explain the long-standing mystery of over-occurrence of shell-type remnants in the Galaxy.

The results of this effort will be published in the Astrophysical Journal Letters.

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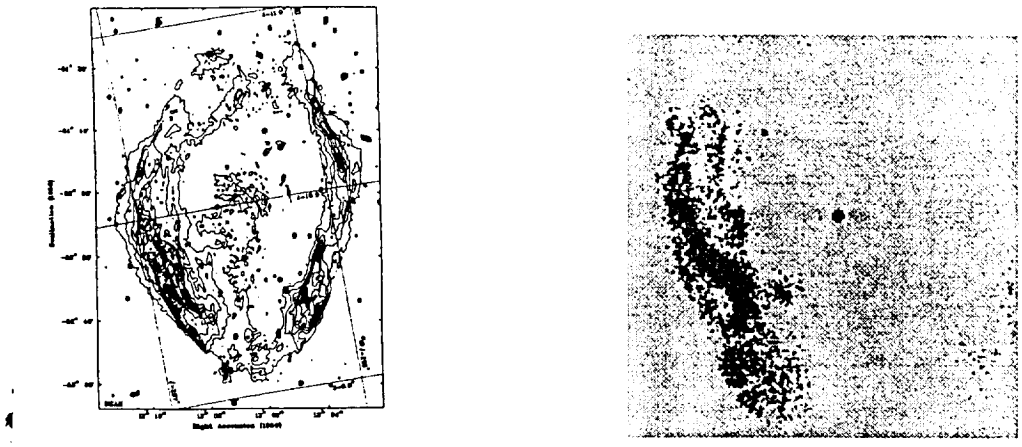

(A) Parkes/Molonglo (B) ROSAT PSPC

Figure 1: (A) An 843 GHz map of PKS 1209−51/52 (or G 296.5+10.0) from combined Parkes and Molonglo observations by Roger et al. (1988). Contours range from 4 to 52 mJy beam^{-1} (beam is $44'' \times 56''$). (B) Archival ROSAT PSPC image of PKS 1209−51/52 showing the central point source 1E 1207.4−5209. The image was produced by convolving the raw image with a circular Gaussian of $\sigma = 1.5$ pixels.

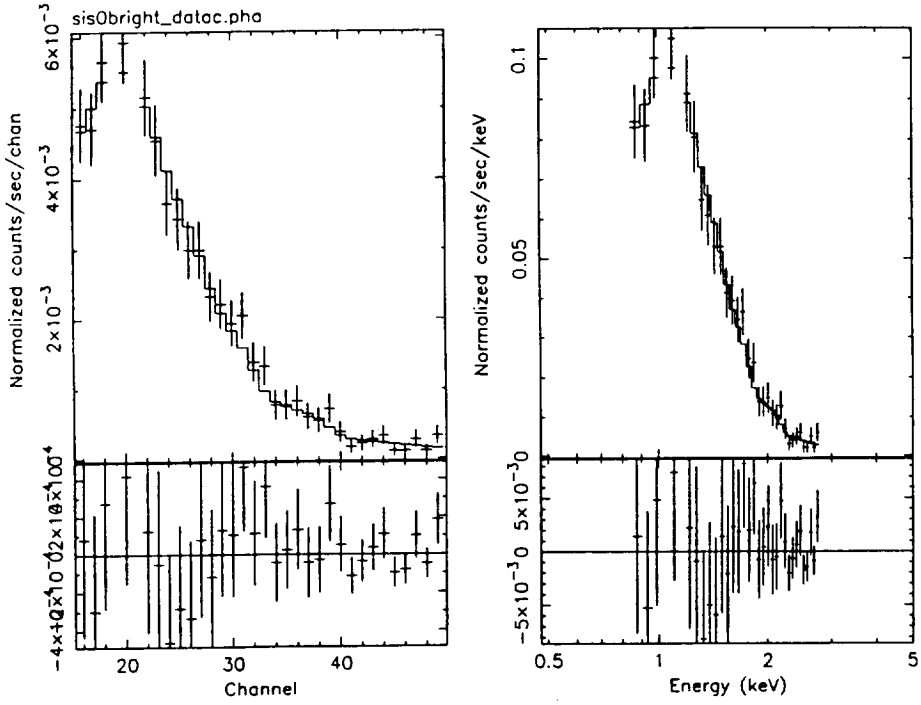

Figure 2: Displayed are two plots of the 1E 1207−5209 spectrum with separate abscissa: i) ASCA SIS energy channel number and ii) energy in keV. The spectra are fit to photons selected from a region surrounding the X-ray source from which the background has been subtracted. The best obtained fits are shown: an absorbed blackbody law with temperature $kT = 0.28$ keV and an intermediate absorbing column density of hydrogen of $N_H = 410^{20}$ cm^{-2}.